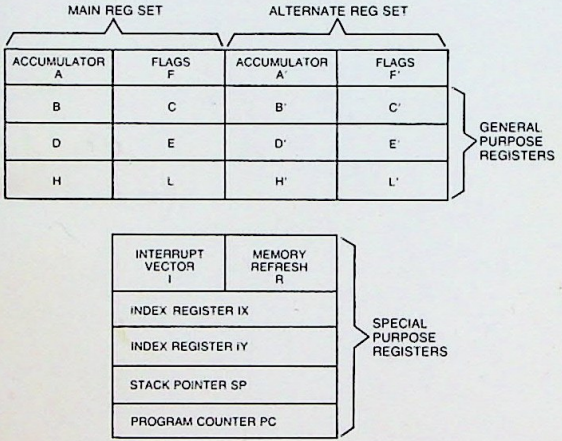
MOSTEK

Z80 MICROCOMPUTER SYSTEM

Micro-Reference Manual



Z80-CPU REGISTER CONFIGURATION

SUMMARY OF FLAG OPERATION

Instruction	D7 S	Z		H		P/V	N	C	D0 Comments
ADD A, s; ADC A, s	↕	↕	X	↕	X	V	0	↕	8 bit add or add with carry
SUB s; SBC A, s; CP s; NEG	↕	↕	X	↕	X	V	1	↕	8 bit subtract, subtract with carry, compare and negate accumulator
AND s	↕	↕	X	1	X	P	0	0	Logical operations
OR s; XOR s	↕	↕	X	0	X	P	0	0	
INC s	↕	↕	X	↕	X	V	0	•	8 bit increment
DEC s	↕	↕	X	↕	X	V	1	•	8 bit decrement
ADD DD, SS	•	•	X	X	X	•	0	↕	16-bit add
ADC HL, SS	↕	↕	X	X	X	V	0	↕	16 bit add with carry
SBC HL, SS	↕	↕	X	X	X	V	1	↕	16-bit subtract with carry
RLA; RLCA; RRA; RRCA	•	•	X	0	X	•	0	↕	Rotate accumulator
RL s; RLC s; RR s; RRC s; SLA s; SRA s; SRL s	↕	↕	X	0	X	P	0	↕	Rotate and shift locations
RLD; RRD	↕	↕	X	0	X	P	0	•	Rotate digit left and right
DAA	↕	↕	X	↕	X	P	•	↕	Decimal adjust accumulator
CPL	•	•	X	1	X	•	1	•	Complement accumulator
SCF	•	•	X	0	X	•	0	1	Set carry
CCF	•	•	X	X	X	•	0	↕	Complement carry
IN r, (C)	↕	↕	X	0	X	P	0	•	Input register indirect
INI; IND; OUTI; OUTD	X	↕	X	X	X	X	1	•	Block input and output
INIR; INDR; OTIR; OTDR	X	1	X	X	X	X	1	•	Z = 0 if B ≠ 0 otherwise Z = 1
LDI; LDD	X	X	X	0	X	↕	0	•	Block transfer instructions
LDIR; LDDR	X	X	X	0	X	0	0	•	P/V = 1 if BC ≠ 0, otherwise P/V = 0
CPI; CPIR; CPD; CPDR	X	↕	X	X	X	↕	1	•	Block search instructions Z = 1 if A = (HL), otherwise Z = 0 P/V = 1 if BC ≠ 0, otherwise P/V = 0
LD A, I; LD A, R	↕	↕	X	0	X	IFF	0	•	The content of the interrupt enable flip-flop (IFF) is copied into the P/V flag
BIT b, s	X	↕	X	1	X	X	0	•	The state of bit b of location s is copied into the Z flag

The following notation is used in this table:

Symbol	Operation
C	Carry/link flag. C=1 if the operation produced a carry from the MSB of the operand or result.
Z	Zero flag. Z=1 if the result of the operation is zero.
S	Sign flag. S=1 if the MSB of the result is one.
P/V	Parity or overflow flag. Parity (P) and overflow (V) share the same flag. Logical operations affect this flag with the parity of the result while arithmetic operations affect this flag with the overflow of the result. If P/V holds parity, P/V=1 if the result of the operation is even, P/V=0 if result is odd. If P/V holds overflow, P/V=1 if the result of the operation produced an overflow.
H	Half carry flag. H=1 if the add or subtract operation produced a carry into or borrow from bit 4 of the accumulator.
N	Add/Subtract flag. N=1 if the previous operation was a subtract. H and N flags are used in conjunction with the decimal adjust instruction (DAA) to properly correct the result into packed BCD format following addition or subtraction using operands with packed BCD format.
↕	The flag is affected according to the result of the operation.
•	The flag is unchanged by the operation.
0	The flag is reset by the operation.
1	The flag is set by the operation.
X	The flag is a "don't care".
V	P/V flag affected according to the overflow result of the operation.
P	P/V flag affected according to the parity result of the operation.
r	Any one of the CPU registers A, B, C, D, E, H, L.
s	Any 8 bit location for all the addressing modes allowed for the particular instruction.
ss	Any 16 bit location for all the addressing modes allowed for that instruction.
ii	Any one of the two index registers IX or IY.
R	Refresh counter.
n	8 bit value in range <0, 255>
nn	16 bit value in range <0, 65535>

8-BIT LOAD GROUP
'LD'

DESTINATION		SOURCE																
		IMPLIED		REGISTER							REG INDIRECT			INDEXED		EXT. ADDR.	IMME.
		I	R	A	B	C	D	E	H	L	(HL)	(BC)	(DE)	(IX+d)	(IY+d)	(nn)	n
REGISTER	A	ED 57	ED 5F	7F	78	79	7A	7B	7C	7D	7E	0A	1A	DD 7E d	FD 7E d	3A n n	3E n
	B			47	40	41	42	43	44	45	46			DD 46 d	FD 46 d		06 n
	C			4F	48	49	4A	4B	4C	4D	4E			DD 4E d	FD 4E d		0E n
	D			57	50	51	52	53	54	55	56			DD 56 d	FD 56 d		16 n
	E			5F	58	59	5A	5B	5C	5D	5E			DD 5E d	FD 5E d		1E n
	H			67	60	61	62	63	64	65	66			DD 66 d	FD 66 d		26 n
	L			6F	68	69	6A	6B	6C	6D	6E			DD 6E d	FD 6E d		2E n
REG INDIRECT	(HL)			77	70	71	72	73	74	75							36 n
	(BC)			02													
	(DE)			12													
INDEXED	(IX+d)			DD 77 d	DD 70 d	DD 71 d	DD 72 d	DD 73 d	DD 74 d	DD 75 d							DD 36 d n
	(IY+d)			FD 77 d	FD 70 d	FD 71 d	FD 72 d	FD 73 d	FD 74 d	FD 75 d							FD 36 d n
EXT.ADDR.	(nn)			32 n n													
IMPLIED	I			ED 47													
	R			ED 4F													

Mnemonic	Symbolic Operation	Flags S	Z		H		P/V	N	C	Op-Code 76 543 210	Hex	No. of Bytes	No. of M Cycles	No. of T States	Comments
LD r, s	r ← s	•	•	X	•	X	•	•	•	01 r s		1	1	4	r, s Reg.
LD r, n	r ← n	•	•	X	•	X	•	•	•	00 r 110 ← n →		2	2	7	000 B 001 C
LD r, (HL)	r ← (HL)	•	•	X	•	X	•	•	•	01 r 110		1	2	7	010 D
LD r, (IX+d)	r ← (IX+d)	•	•	X	•	X	•	•	•	11 011 101 01 r 110 ← d →	DD	3	5	19	011 E 100 H 101 L
LD r, (IY+d)	r ← (IY+d)	•	•	X	•	X	•	•	•	11 111 101 01 r 110 ← d →	FD	3	5	19	111 A
LD (HL), r	(HL) ← r	•	•	X	•	X	•	•	•	01 110 r		1	2	7	
LD (IX+d), r	(IX+d) ← r	•	•	X	•	X	•	•	•	11 011 101 01 110 r ← d →	DD	3	5	19	
LD (IY+d), r	(IY+d) ← r	•	•	X	•	X	•	•	•	11 111 101 01 110 r ← d →	FD	3	5	19	
LD (HL), n	(HL) ← n	•	•	X	•	X	•	•	•	00 110 110 ← n →	36	2	3	10	
LD (IX+d), n	(IX+d) ← n	•	•	X	•	X	•	•	•	11 011 101 00 110 110 ← d → ← n →	DD 36	4	5	19	
LD (IY+d), n	(IY+d) ← n	•	•	X	•	X	•	•	•	11 111 101 00 110 110 ← d → ← n →	FD 36	4	5	19	
LD A, (BC)	A ← (BC)	•	•	X	•	X	•	•	•	00 001 010	0A	1	2	7	
LD A, (DE)	A ← (DE)	•	•	X	•	X	•	•	•	00 011 010	1A	1	2	7	
LD A, (nn)	A ← (nn)	•	•	X	•	X	•	•	•	00 111 010 ← n → ← n →	3A	3	4	13	
LD (BC), A	(BC) ← A	•	•	X	•	X	•	•	•	00 000 010	02	1	2	7	
LD (DE), A	(DE) ← A	•	•	X	•	X	•	•	•	00 010 010	12	1	2	7	
LD (nn), A	(nn) ← A	•	•	X	•	X	•	•	•	00 110 010 ← n → ← n →	32	3	4	13	
LD A, I	A ← I	↕	↕	X	0	X	IFF	0	•	11 101 101 01 010 111	ED 57	2	2	9	
LD A, R	A ← R	↕	↕	X	0	X	IFF	0	•	11 101 101 01 011 111	ED 5F	2	2	9	
LD I, A	I ← A	•	•	X	•	X	•	•	•	11 101 101 01 000 111	ED 47	2	2	9	
LD R, A	R ← A	•	•	X	•	X	•	•	•	11 101 101 01 001 111	ED 4F	2	2	9	

Notes: r, s means any of the registers A, B, C, D, E, H, L
IFF the content of the interrupt enable flip-flop (IFF) is copied into the P/V flag

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown,
↕ = flag is affected according to the result of the operation.

16-BIT LOAD GROUP
'LD'
'PUSH' AND 'POP'

			SOURCE									
			REGISTER							IMM. EXT.	EXT. ADDR.	REG. INDIR.
			AF	BC	DE	HL	SP	IX	IY	nn	(nn)	(SP)
DESTINATION	REGISTER	AF										F1
		BC								01 n n	ED 4B n n	C1
		DE								11 n n	ED 5B n n	D1
		HL								21 n n	2A n n	E1
		SP				F9		DD F9	FD F9	31 n n	ED 7B n n	
		IX								DD 21 n n	DD 2A n n	DD E1
		IY								FD 21 n n	FD 2A n n	FD E1
	EXT. ADDR.	(nn)		ED 43 n n	ED 53 n n	22 n n	ED 73 n n	DD 22 n n	FD 22 n n			
PUSH INSTRUCTIONS →	REG. IND.	(SP)	F5	C5	D5	E5		DD E5	FD E5			

NOTE: The Push & Pop Instructions adjust the SP after every execution.

POP INSTRUCTIONS ↑

Mnemonic	Symbolic Operation	Flags S	Z		H		P/V	N	C	Op-Code 76 543 210	Hex	No. of Bytes	No. of M Cycles	No. of T States	Comments
LD dd, nn	dd ← nn	•	•	X	•	X	•	•	•	00 dd0 001 ← n → ← n →		3	3	10	dd Pair 00 BC 01 DE
LD IX, nn	IX ← nn	•	•	X	•	X	•	•	•	11 011 101 00 100 001 ← n → ← n →	DD 21	4	4	14	10 HL 11 SP
LD IY, nn	IY ← nn	•	•	X	•	X	•	•	•	11 111 101 00 100 001 ← n → ← n →	FD 21	4	4	14	
LD HL, (nn)	H ← (nn+1) L ← (nn)	•	•	X	•	X	•	•	•	00 101 010 ← n → ← n →	2A	3	5	16	
LD dd, (nn)	dd_H ← (nn+1) dd_L ← (nn)	•	•	X	•	X	•	•	•	11 101 101 01 dd1 011 ← n → ← n →	ED	4	6	20	
LD IX, (nn)	IX_H ← (nn+1) IX_L ← (nn)	•	•	X	•	X	•	•	•	11 011 101 00 101 010 ← n → ← n →	DD 2A	4	6	20	
LD IY, (nn)	IY_H ← (nn+1) IY_L ← (nn)	•	•	X	•	X	•	•	•	11 111 101 00 101 010 ← n → ← n →	FD 2A	4	6	20	
LD (nn), HL	(nn+1) ← H (nn) ← L	•	•	X	•	X	•	•	•	00 100 010 ← n → ← n →	22	3	5	16	
LD (nn), dd	(nn+1) ← dd_H (nn) ← dd_L	•	•	X	•	X	•	•	•	11 101 101 01 dd0 011 ← n → ← n →	ED	4	6	20	
LD (nn), IX	(nn+1) ← IX_H (nn) ← IX_L	•	•	X	•	X	•	•	•	11 011 101 00 100 010 ← n → ← n →	DD 22	4	6	20	
LD (nn), IY	(nn+1) ← IY_H (nn) ← IY_L	•	•	X	•	X	•	•	•	11 111 101 00 100 010 ← n → ← n →	FD 22	4	6	20	
LD SP, HL	SP ← HL	•	•	X	•	X	•	•	•	11 111 001	F9	1	1	6	
LD SP, IX	SP ← IX	•	•	X	•	X	•	•	•	11 011 101 11 111 001	DD F9	2	2	10	
LD SP, IY	SP ← IY	•	•	X	•	X	•	•	•	11 111 101 11 111 001	FD F9	2	2	10	
PUSH qq	(SP-2) ← qqL (SP-1) ← qqH	•	•	X	•	X	•	•	•	11 qq0 101		1	3	11	qq Pair 00 BC 01 DE
PUSH IX	(SP-2) ← IX_L (SP-1) ← IX_H	•	•	X	•	X	•	•	•	11 011 101 11 100 101	DD E5	2	4	15	10 HL 11 AF
PUSH IY	(SP-2) ← IY_L (SP-1) ← IY_H	•	•	X	•	X	•	•	•	11 111 101 11 100 101	FD E5	2	4	15	
POP qq	qqH ← (SP+1) qqL ← (SP)	•	•	X	•	X	•	•	•	11 qq0 001		1	3	10	
POP IX	IX_H ← (SP+1) IX_L ← (SP)	•	•	X	•	X	•	•	•	11 011 101 11 100 001	DD E1	2	4	14	
POP IY	IY_H ← (SP+1) IY_L ← (SP)	•	•	X	•	X	•	•	•	11 111 101 11 100 001	FD E1	2	4	14	

Notes: dd is any of the register pairs BC, DE, HL, SP
qq is any of the register pairs AF, BC, DE, HL
$(PAIR)_H$, $(PAIR)_L$ refer to high order and low order eight bits of the register pair respectively.
e.g. BC_L = C, AF_H = A

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown,
↕ flag is affected according to the result of the operation.

EXCHANGES
'EX' AND 'EXX'

		IMPLIED ADDRESSING				
		AF'	BC', DE' & HL'	HL	IX	IY
IMPLIED	AF	08				
	BC, DE & HL		D9			
	DE			EB		
REG. INDIR.	(SP)			E3	DD E3	FD E3

BLOCK TRANSFER GROUP

			SOURCE: REG. INDIR.	SOURCE: (HL)	
DESTINATION	REG. INDIR.	(DE)	ED	A0	'LDI' – Load (DE) ← (HL) Inc HL & DE, Dec BC
			ED	B0	'LDIR' – Load (DE)←(HL) Inc HL & DE, Dec BC, Repeat until BC = 0
			ED	A8	'LDD' – Load (DE) ← (HL) Dec HL & DE, Dec BC
			ED	B8	'LDDR' – Load (DE)←(HL) Dec HL & DE, Dec BC, Repeat until BC = 0

HL points to source
DE points to destination
BC is byte counter

BLOCK SEARCH GROUP

SEARCH LOCATION: REG. INDIR.	SEARCH LOCATION: (HL)	
ED	A1	'CPI' Inc HL, Dec BC
ED	B1	'CPIR' – Inc HL, Dec BC repeat until BC = 0 or find match
ED	A9	'CPD' – Dec HL & BC
ED	B9	'CPDR' – Dec HL & BC Repeat until BC = 0 or find match

HL points to location in memory to be compared with accumulator contents
BC is byte counter

EXCHANGE GROUP AND BLOCK TRANSFER AND SEARCH GROUP

Mnemonic	Symbolic Operation	Flags S	Z		H		P/V	N	C	Op-Code 76 543 210	Hex	No. of Bytes	No. of M Cycles	No. of T States	Comments
EX DE, HL	DE ↔ HL	•	•	X	•	X	•	•	•	11 101 011	EB	1	1	4	
EX AF, AF'	AF ↔ AF'	•	•	X	•	X	•	•	•	00 001 000	08	1	1	4	
EXX	BC ↔ BC' DE ↔ DE' HL ↔ HL'	•	•	X	•	X	•	•	•	11 011 001	D9	1	1	4	Register bank and auxiliary register bank exchange
EX (SP), HL	H ↔ (SP+1) L ↔ (SP)	•	•	X	•	X	•	•	•	11 100 011	E3	1	5	19	
EX (SP), IX	IX_H ↔ (SP+1) IX_L ↔ (SP)	•	•	X	•	X	•	•	•	11 011 101 11 100 011	DD E3	2	6	23	
EX (SP), IY	IY_H ↔ (SP+1) IY_L ↔ (SP)	•	•	X	•	X	•	•	•	11 111 101 11 100 011	FD E3	2	6	23	
LDI	(DE) ← (HL) DE ← DE+1 HL ← HL+1 BC ← BC-1	•	•	X	0	X	↕ (1)	0	•	11 101 101 10 100 000	ED A0	2	4	16	Load (HL) into (DE), increment the pointers and decrement the byte counter (BC)
LDIR	(DE) ← (HL) DE ← DE+1 HL ← HL+1 BC ← BC-1 Repeat until BC = 0	•	•	X	0	X	0	0	•	11 101 101 10 110 000	ED B0	2 2	5 4	21 16	If BC ≠ 0 If BC = 0
LDD	(DE) ← (HL) DE ← DE-1 HL ← HL-1 BC ← BC-1	•	•	X	0	X	↕ (1)	0	•	11 101 101 10 101 000	ED A8	2	4	16	
LDDR	(DE) ← (HL) DE ← DE-1 HL ← HL-1 BC ← BC-1 Repeat until BC = 0	•	•	X	0	X	0	0	•	11 101 101 10 111 000	ED B8	2 2	5 4	21 16	If BC ≠ 0 If BC = 0
CPI	A − (HL) HL ← HL+1 BC ← BC-1	↕	↕ (2)	X	↕	X	↕ (1)	1	•	11 101 101 10 100 001	ED A1	2	4	16	
CPIR	A − (HL) HL ← HL+1 BC ← BC-1 Repeat until A = (HL) or BC = 0	↕	↕ (2)	X	↕	X	↕ (1)	1	•	11 101 101 10 110 001	ED B1	2 2	5 4	21 16	If BC ≠ 0 and A ≠ (HL) If BC = 0 or A = (HL)
CPD	A − (HL) HL ← HL-1 BC ← BC-1	↕	↕ (2)	X	↕	X	↕ (1)	1	•	11 101 101 10 101 001	ED A9	2	4	16	
CPDR	A − (HL) HL ← HL-1 BC ← BC-1 Repeat until A = (HL) or BC = 0	↕	↕ (2)	X	↕	X	↕ (1)	1	•	11 101 101 10 111 001	ED B9	2 2	5 4	21 16	If BC ≠ 0 and A ≠ (HL) If BC = 0 or A = (HL)

Notes: (1) P/V flag is 0 if the result of BC-1 = 0, otherwise P/V = 1
(2) Z flag is 1 if A = (HL), otherwise Z = 0.

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown, ↕ = flag is affected according to the result of the operation.

SOURCE

	REGISTER ADDRESSING							REG. INDIR.	INDEXED		IMMED.
	A	B	C	D	E	H	L	(HL)	(IX+d)	(IY+d)	n
'ADD'	87	80	81	82	83	84	85	86	DD 86 d	FD 86 d	C6 n
ADD w CARRY 'ADC'	8F	88	89	8A	8B	8C	8D	8E	DD 8E d	FD 8E d	CE n
SUBTRACT 'SUB'	97	90	91	92	93	94	95	96	DD 96 d	FD 96 d	D6 n
SUB w CARRY 'SBC'	9F	98	99	9A	9B	9C	9D	9E	DD 9E d	FD 9E d	DE n
'AND'	A7	A0	A1	A2	A3	A4	A5	A6	DD A6 d	FD A6 d	E6 n
'XOR'	AF	A8	A9	AA	AB	AC	AD	AE	DD AE d	FD AE d	EE n
'OR'	B7	B0	B1	B2	B3	B4	B5	B6	DD B6 d	FD B6 d	F6 n
COMPARE 'CP'	BF	B8	B9	BA	BB	BC	BD	BE	DD BE d	FD BE d	FE n
INCREMENT 'INC'	3C	04	0C	14	1C	24	2C	34	DD 34 d	FD 34 d	
DECREMENT 'DEC'	3D	05	0D	15	1D	25	2D	35	DD 35 d	FD 35 d	

8-BIT ARITHMETIC AND LOGICAL GROUP

Mnemonic	Symbolic Operation	Flags S	Z		H		P/V	N	C	Op-Code 76 543 210	Hex	No. of Bytes	No. of M Cycles	No. of T States	Comments
ADD A, r	A ← A + r	↕	↕	X	↕	X	V	0	↕	10 000 r		1	1	4	r Reg.
ADD A, n	A ← A + n	↕	↕	X	↕	X	V	0	↕	11 000 110 – n –		2	2	7	000 B 001 C 010 D
ADD A, (HL)	A ← A+(HL)	↕	↕	X	↕	X	V	0	↕	10 000 110		1	2	7	011 E
ADD A, (IX+d)	A ← A+(IX+d)	↕	↕	X	↕	X	V	0	↕	11 011 101 10 000 110 – d –	DD	3	5	19	100 H 101 L 111 A
ADD A, (IY+d)	A ← A+(IY+d)	↕	↕	X	↕	X	V	0	↕	11 111 101 10 000 110 – d –	FD	3	5	19	
ADC A, s	A ← A+s+CY	↕	↕	X	↕	X	V	0	↕	001					s is any of r, n, (HL), (IX+d), (IY+d) as shown for ADD instruction. The indicated bits replace the 000 in the ADD set above.
SUB s	A ← A – s	↕	↕	X	↕	X	V	1	↕	010					
SBC A, s	A ← A – s – CY	↕	↕	X	↕	X	V	1	↕	011					
AND s	A ← A ∧ s	↕	↕	X	1	X	P	0	0	100					
OR s	A ← A ∨ s	↕	↕	X	0	X	P	0	0	110					
XOR s	A ← A ⊕ s	↕	↕	X	0	X	P	0	0	101					
CP s	A – s	↕	↕	X	↕	X	V	1	↕	111					
INC r	r ← r + 1	↕	↕	X	↕	X	V	0	•	00 r 100		1	1	4	
INC (HL)	(HL) ← (HL)+1	↕	↕	X	↕	X	V	0	•	00 110 100		1	3	11	
INC (IX+d)	(IX+d) ← (IX+d)+1	↕	↕	X	↕	X	V	0	•	11 011 101 00 110 100 – d –	DD	3	6	23	
INC (IY+d)	(IY+d) ← (IY+d)+1	↕	↕	X	↕	X	V	0	•	11 111 101 00 110 100 – d –	FD	3	6	23	
DEC s	s ← s – 1	↕	↕	X	↕	X	V	1	•	101					s is any of r, (HL), (IX+d), (IY+d) as shown for INC. DEC same format and states as INC. Replace 100 with 101 in OP Code.

Notes: The V symbol in the P/V flag column indicates that the P/V flag contains the overflow of the result of the operation. Similarly the P symbol indicates parity. V = 1 means overflow, V = 0 means not overflow. P = 1 means parity of the result is even, P = 0 means parity of the result is odd.

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown.
↕ = flag is affected according to the result of the operation.

GENERAL PURPOSE AF OPERATIONS

Decimal Adjust Acc, 'DAA'	27
Complement Acc, 'CPL'	2F
Negate Acc, 'NEG' (2's complement)	ED 44
Complement Carry Flag, 'CCF'	3F
Set Carry Flag, 'SCF'	37

MISCELLANEOUS CPU CONTROL

'NOP'	00	
'HALT'	76	
DISABLE INT '(DI)'	F3	
ENABLE INT '(EI)'	FB	
SET INT MODE 0 'IM 0'	ED 46	8080A MODE
SET INT MODE 1 'IM 1'	ED 56	RESTART TO LOCATION 0038H
SET INT MODE 2 'IM 2'	ED 5E	INDIRECT CALL USING REGISTER I AND 8 BITS FROM INTERRUPTING DEVICE AS A POINTER.

GENERAL PURPOSE ARITHMETIC AND CPU CONTROL GROUPS

Mnemonic	Symbolic Operation	Flags								Op-Code		No. of Bytes	No. of M Cycles	No. of T States	Comments
		S	Z		H		P/V	N	C	76 543 210	Hex				
DAA	Converts acc. content into packed BCD following add or subtract with packed BCD operands	↕	↕	X	↕	X	P	•	↕	00 100 111	27	1	1	4	Decimal adjust accumulator
CPL	$A - \overline{A}$	•	•	X	1	X	•	1	•	00 101 111	2F	1	1	4	Complement accumulator (One's complement)
NEG	$A - \overline{A} + 1$	↕	↕	X	↕	X	V	1	↕	11 101 101 01 000 100	ED 44	2	2	8	Negate acc. (two's complement)
CCF	$CY - \overline{CY}$	•	•	X	X	X	•	0	↕	00 111 111	3F	1	1	4	Complement carry flag
SCF	CY - 1	•	•	X	0	X	•	0	1	00 110 111	37	1	1	4	Set carry flag
NOP	No operation	•	•	X	•	X	•	•	•	00 000 000	00	1	1	4	
HALT	CPU halted	•	•	X	•	X	•	•	•	01 110 110	76	1	1	4	
DI *	IFF - 0	•	•	X	•	X	•	•	•	11 110 011	F3	1	1	4	
EI *	IFF - 1	•	•	X	•	X	•	•	•	11 111 011	FB	1	1	4	
IM 0	Set interrupt mode 0	•	•	X	•	X	•	•	•	11 101 101 01 000 110	ED 46	2	2	8	
IM 1	Set interrupt mode 1	•	•	X	•	X	•	•	•	11 101 101 01 010 110	ED 56	2	2	8	
IM 2	Set interrupt mode 2	•	•	X	•	X	•	•	•	11 101 101 01 011 110	ED 5E	2	2	8	

Notes: IFF indicates the interrupt enable flip-flop
CY indicates the carry flip-flop.

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown,
↕ = flag is affected according to the result of the operation.
* = Interrupts are not sampled at the end of EI or DI

16-BIT ARITHMETIC

DESTINATION			SOURCE BC	DE	HL	SP	IX	IY
	'ADD'	HL	09	19	29	39		
		IX	DD 09	DD 19		DD 39	DD 29	
		IY	FD 09	FD 19		FD 39		FD 29
	ADD WITH CARRY AND SET FLAGS 'ADC'	HL	ED 4A	ED 5A	ED 6A	ED 7A		
	SUB WITH CARRY AND SET FLAGS 'SBC'	HL	ED 42	ED 52	ED 62	ED 72		
	INCREMENT 'INC'		03	13	23	33	DD 23	FD 23
	DECREMENT 'DEC'		0B	1B	2B	3B	DD 2B	FD 2B

Mnemonic	Symbolic Operation	Flags S	Z		H		P/V	N	C	Op-Code 76 543 210	Hex	No. of Bytes	No. of M Cycles	No. of T States	Comments
ADD HL, ss	HL ← HL+ss	•	•	X	X	X	•	0	↕	00 ss1 001		1	3	11	ss Reg. 00 BC 01 DE 10 HL 11 SP
ADC HL, ss	HL ← HL+ss+CY	↕	↕	X	X	X	V	0	↕	11 101 101 01 ss1 010	ED	2	4	15	
SBC HL, ss	HL ← HL-ss-CY	↕	↕	X	X	X	V	1	↕	11 101 101 01 ss0 010	ED	2	4	15	
ADD IX, pp	IX ← IX + pp	•	•	X	X	X	•	0	↕	11 011 101 00 pp1 001	DD	2	4	15	pp Reg. 00 BC 01 DE 10 IX 11 SP
ADD IY, rr	IY ← IY + rr	•	•	X	X	X	•	0	↕	11 111 101 00 rr1 001	FD	2	4	15	rr Reg. 00 BC 01 DE 10 IY 11 SP
INC ss	ss ← ss + 1	•	•	X	•	X	•	•	•	00 ss0 011		1	1	6	
INC IX	IX ← IX + 1	•	•	X	•	X	•	•	•	11 011 101 00 100 011	DD 23	2	2	10	
INC IY	IY ← IY + 1	•	•	X	•	X	•	•	•	11 111 101 00 100 011	FD 23	2	2	10	
DEC ss	ss ← ss - 1	•	•	X	•	X	•	•	•	00 ss1 011		1	1	6	
DEC IX	IX ← IX - 1	•	•	X	•	X	•	•	•	11 011 101 00 101 011	DD 2B	2	2	10	
DEC IY	IY ← IY - 1	•	•	X	•	X	•	•	•	11 111 101 00 101 011	FD 2B	2	2	10	

Notes: ss is any of the register pairs BC, DE, HL, SP
pp is any of the register pairs BC, DE, IX, SP
rr is any of the register pairs BC, DE, IY, SP.

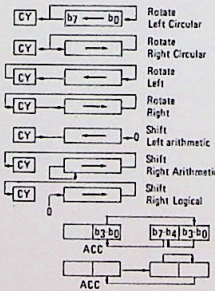
Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown.
↕ = flag is affected according to the result of the operation.

ROTATES AND SHIFTS

Source and Destination

TYPE OF ROTATE OR SHIFT	A	B	C	D	E	H	L	(HL)	(IX+d)	(IY+d)
'RLC'	CB 07	CB 00	CB 01	CB 02	CB 03	CB 04	CB 05	CB 06	DD CB d 06	FD CB d 06
'RRC'	CB 0F	CB 08	CB 09	CB 0A	CB 0B	CB 0C	CB 0D	CB 0E	DD CB d 0E	FD CB d 0E
'RL'	CB 17	CB 10	CB 11	CB 12	CB 13	CB 14	CB 15	CB 16	DD CB d 16	FD CB d 16
'RR'	CB 1F	CB 18	CB 19	CB 1A	CB 1B	CB 1C	CB 1D	CB 1E	DD CB d 1E	FD CB d 1E
'SLA'	CB 27	CB 20	CB 21	CB 22	CB 23	CB 24	CB 25	CB 26	DD CB d 26	FD CB d 26
'SRA'	CB 2F	CB 28	CB 29	CB 2A	CB 2B	CB 2C	CB 2D	CB 2E	DD CB d 2E	FD CB d 2E
'SRL'	CB 3F	CB 38	CB 39	CB 3A	CB 3B	CB 3C	CB 3D	CB 3E	DD CB d 3E	FD CB d 3E
'RLD'								ED 6F		
'RRD'								ED 67		

	A
'RLCA'	07
'RRCA'	0F
'RLA'	17
'RRA'	1F



Mnemonic	Symbolic Operation	Flags S	Z		H		P/V	N	C	Op-Code 76 543 210	Hex	No. of Bytes	No. of M Cycles	No. of T States	Comments
RLCA		•	•	X	0	X	•	0	↕	00 000 111	07	1	1	4	Rotate left circular accumulator
RLA		•	•	X	0	X	•	0	↕	00 010 111	17	1	1	4	Rotate left accumulator
RRCA		•	•	X	0	X	•	0	↕	00 001 111	0F	1	1	4	Rotate right circular accumulator
RRA		•	•	X	0	X	•	0	↕	00 011 111	1F	1	1	4	Rotate right accumulator
RLC r		↕	↕	X	0	X	P	0	↕	11 001 011 00 000 r	CB	2	2	8	Rotate left circular register r
RLC (HL)		↕	↕	X	0	X	P	0	↕	11 001 011 00 000 110	CB	2	4	15	r Reg. 000 B 001 C
RLC (IX+d)	r,(HL),(IX+d),(IY+d)	↕	↕	X	0	X	P	0	↕	11 011 101 11 001 011 – d – 00 000 110	DD CB	4	6	23	010 D 011 E 100 H 101 L 111 A
RLC (IY+d)		↕	↕	X	0	X	P	0	↕	11 111 101 11 001 011 – d – 00 000 110	FD CB	4	6	23	
RL s	s ≡ r,(HL),(IX+d),(IY+d)	↕	↕	X	0	X	P	0	↕	010					Instruction format and states are as shown for RLC's. To form new Op-Code replace 000 of RLC's with shown code
RRC s	s ≡ r,(HL),(IX+d),(IY+d)	↕	↕	X	0	X	P	0	↕	001					
RR s	s ≡ r,(HL),(IX+d),(IY+d)	↕	↕	X	0	X	P	0	↕	011					
SLA s	s ≡ r,(HL),(IX+d),(IY+d)	↕	↕	X	0	X	P	0	↕	100					
SRA s	s ≡ r,(HL),(IX+d),(IY+d)	↕	↕	X	0	X	P	0	↕	101					
SRL s		↕	↕	X	0	X	P	0	↕	111					
RLD		↕	↕	X	0	X	P	0	•	11 101 101 01 101 111	ED 6F	2	5	18	Rotate digit left and right between the accumulator and location (HL). The content of the upper half of the accumulator is unaffected
RRD		↕	↕	X	0	X	P	0	•	11 101 101 01 100 111	ED 67	2	5	18	

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown,
↕ = flag is affected according to the result of the operation.

BIT MANIPULATION GROUP

		REGISTER ADDRESSING							REG. INDIR.	INDEXED	
	BIT	A	B	C	D	E	H	L	(HL)	(IX+d)	(IY+d)
TEST 'BIT'	0	CB 47	CB 40	CB 41	CB 42	CB 43	CB 44	CB 45	CB 46	DD CB d 46	FD CB d 46
	1	CB 4F	CB 48	CB 49	CB 4A	CB 4B	CB 4C	CB 4D	CB 4E	DD CB d 4E	FD CB d 4E
	2	CB 57	CB 50	CB 51	CB 52	CB 53	CB 54	CB 55	CB 56	DD CB d 56	FD CB d 56
	3	CB 5F	CB 58	CB 59	CB 5A	CB 5B	CB 5C	CB 5D	CB 5E	DD CB d 5E	FD CB d 5E
	4	CB 67	CB 60	CB 61	CB 62	CB 63	CB 64	CB 65	CB 66	DD CB d 66	FD CB d 66
	5	CB 6F	CB 68	CB 69	CB 6A	CB 6B	CB 6C	CB 6D	CB 6E	DD CB d 6E	FD CB d 6E
	6	CB 77	CB 70	CB 71	CB 72	CB 73	CB 74	CB 75	CB 76	DD CB d 76	FD CB d 76
	7	CB 7F	CB 78	CB 79	CB 7A	CB 7B	CB 7C	CB 7D	CB 7E	DD CB d 7E	FD CB d 7E
RESET BIT 'RES'	0	CB B7	CB B0	CB B1	CB B2	CB B3	CB B4	CB B5	CB B6	DD CB d B6	FD CB d B6
	1	CB BF	CB B8	CB B9	CB BA	CB BB	CB BC	CB BD	CB BE	DD CB d BE	FD CB d BE
	2	CB 97	CB 90	CB 91	CB 92	CB 93	CB 94	CB 95	CB 96	DD CB d 96	FD CB d 96
	3	CB 9F	CB 98	CB 99	CB 9A	CB 9B	CB 9C	CB 9D	CB 9E	DD CB d 9E	FD CB d 9E
	4	CB A7	CB A0	CB A1	CB A2	CB A3	CB A4	CB A5	CB A6	DD CB d A6	FD CB d A6
	5	CB AF	CB A8	CB A9	CB AA	CB AB	CB AC	CB AD	CB AE	DD CB d AE	FD CB d AE
	6	CB B7	CB B0	CB B1	CB B2	CB B3	CB B4	CB B5	CB B6	DD CB d B6	FD CB d B6
	7	CB BF	CB B8	CB B9	CB BA	CB BB	CB BC	CB BD	CB BE	DD CB d BE	FD CB d BE
SET BIT 'SET'	0	CB C7	CB C0	CB C1	CB C2	CB C3	CB C4	CB C5	CB C6	DD CB d C6	FD CB d C6
	1	CB CF	CB C8	CB C9	CB CA	CB CB	CB CC	CB CD	CB CE	DD CB d CE	FD CB d CE
	2	CB D7	CB D0	CB D1	CB D2	CB D3	CB D4	CB D5	CB D6	DD CB d D6	FD CB d D6
	3	CB DF	CB D8	CB D9	CB DA	CB DB	CB DC	CB DD	CB DE	DD CB d DE	FD CB d DE
	4	CB E7	CB E0	CB E1	CB E2	CB E3	CB E4	CB E5	CB E6	DD CB d E6	FD CB d E6
	5	CB EF	CB E8	CB E9	CB EA	CB EB	CB EC	CB ED	CB EE	DD CB d EE	FD CB d EE
	6	CB F7	CB F0	CB F1	CB F2	CB F3	CB F4	CB F5	CB F6	DD CB d F6	FD CB d F6
	7	CB FF	CB F8	CB F9	CB FA	CB FB	CB FC	CB FD	CB FE	DD CB d FE	FD CB d FE

BIT SET, RESET AND TEST GROUP

Mnemonic	Symbolic Operation	Flags S	Z		H		P/V	N	C	Op-Code 76 543 210	Hex	No. of Bytes	No.of M Cycles	No.of T States	Comments
BIT b, r	$Z \leftarrow \overline{r_b}$	X	↕	X	1	X	X	0	•	11 001 011 01 b r	CB	2	2	8	r: 000 B, 001 C, 010 D, 011 E, 100 H, 101 L, 111 A
BIT b, (HL)	$Z \leftarrow \overline{(HL)_b}$	X	↕	X	1	X	X	0	•	11 001 011 01 b 110	CB	2	3	12	b: 000 0, 001 1, 010 2, 011 3, 100 4, 101 5, 110 6, 111 7
BIT b, (IX+d)$_b$	$Z \leftarrow \overline{(IX+d)_b}$	X	↕	X	1	X	X	0	•	11 011 101 11 001 011 – d – 01 b 110	DD CB	4	5	20	
BIT b, (IY+d)$_b$	$Z \leftarrow \overline{(IY+d)_b}$	X	↕	X	1	X	X	0	•	11 111 101 11 001 011 – d – 01 b 110	FD CB	4	5	20	
SET b, r	$r_b \leftarrow 1$	•	•	X	•	X	•	•	•	11 001 011 11 b r	CB	2	2	8	
SET b, (HL)	$(HL)_b \leftarrow 1$	•	•	X	•	X	•	•	•	11 001 011 11 b 110	CB	2	4	15	
SET b, (IX+d)	$(IX+d)_b \leftarrow 1$	•	•	X	•	X	•	•	•	11 011 101 11 001 011 – d – 11 b 110	DD CB	4	6	23	
SET b, (IY+d)	$(IY+d)_b \leftarrow 1$	•	•	X	•	X	•	•	•	11 111 101 11 001 011 – d – 11 b 110	FD CB	4	6	23	
RES b, s	$s_b \leftarrow 0$ s ≡ r, (HL), (IX+d), (IY+d)	•	•	X	•	X	•	•	•	10					To form new Op Code replace 11 of SET b, s with 10. Flags and time states for SET instruction

Notes: The notation s_b indicates bit b (0 to 7) of location s.

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown,
↕ = flag is affected according to the result of the operation.

JUMP GROUP

CONDITION

			UN COND	CARRY	NON CARRY	ZERO	NON ZERO	PARITY EVEN	PARITY ODD	SIGN NEG	SIGN POS	REG B ≠ 0
JUMP 'JP'	IMMED. EXT.	nn	C3 n n	DA n n	D2 n n	CA n n	C2 n n	EA n n	E2 n n	FA n n	F2 n n	
JUMP 'JR'	RELATIVE	PC + e	18 e 2	38 e 2	30 e 2	28 e 2	20 e 2					
JUMP 'JP'	REG. INDIR.	(HL)	E9									
JUMP 'JP'		(IX)	DD E9									
JUMP 'JP'		(IY)	FD E9									
DECREMENT B, JUMP IF NON ZERO 'DJNZ'	RELATIVE	PC + e										10 e 2

Mnemonic	Symbolic Operation	Flags S	Z		H		P/V	N	C	Op Code 76 543 210	Hex	No. of Bytes	No.of M Cycles	No.of T States	Comments
JP nn	PC ← nn	•	•	X	•	X	•	•	•	11 000 011 ← n ← ← n ←	C3	3	3	10	
JP cc, nn	If condition cc is true PC ← nn, otherwise continue	•	•	X	•	X	•	•	•	11 cc 010 ← n ← ← n ←		3	3	10	cc Condition 000 NZ non zero 001 Z zero 010 NC non carry 011 C carry 100 PO parity odd 101 PE parity even 110 P sign positive 111 M sign negative
JR e	PC ← PC + e	•	•	X	•	X	•	•	•	00 011 000 ← e-2 ←	18	2	3	12	
JR C, e	If C = 0, continue If C = 1, PC ← PC+e	•	•	X	•	X	•	•	•	00 111 000 ← e-2 ←	38	2 2	2 3	7 12	If condition not met If condition is met
JR NC, e	If C = 1, continue If C = 0, PC ← PC+e	•	•	X	•	X	•	•	•	00 110 000 ← e-2 ←	30	2 2	2 3	7 12	If condition not met If condition is met
JR Z, e	If Z = 0 continue If Z = 1, PC ← PC+e	•	•	X	•	X	•	•	•	00 101 000 ← e-2 ←	28	2 2	2 3	7 12	If condition not met If condition is met
JR NZ, e	If Z = 1, continue If Z = 0, PC ← PC+e	•	•	X	•	X	•	•	•	00 100 000 ← e-2 ←	20	2 2	2 3	7 12	If condition not met If condition is met
JP (HL)	PC ← HL	•	•	X	•	X	•	•	•	11 101 001	E9	1	1	4	
JP (IX)	PC ← IX	•	•	X	•	X	•	•	•	11 011 101 11 101 001	DD E9	2	2	8	
JP (IY)	PC ← IY	•	•	X	•	X	•	•	•	11 111 101 11 101 001	FD E9	2	2	8	
DJNZ, e	B ← B-1 If B = 0, continue	•	•	X	•	X	•	•	•	00 010 000 ← e-2 ←	10	2	2	8	If B = 0
	If B ≠ 0, PC ← PC+e											2	3	13	If B ≠ 0

Notes: e represents the extension in the relative addressing mode.
e is a signed two's complement number in the range <126, 129>
e-2 in the op code provides an effective address of pc+e as PC is incremented by 2 prior to the addition of e.

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown.
↕ = flag is affected according to the result of the operation.

CALL AND RETURN GROUP

			CONDITION										
			UN-COND.	CARRY	NON CARRY	ZERO	NON ZERO	PARITY EVEN	PARITY ODD	SIGN NEG.	SIGN POS.	REG. B ≠ 0
'CALL'	IMMED. EXT.	nn	CD n n	DC n n	D4 n n	CC n n	C4 n n	EC n n	E4 n n	FC n n	F4 n n	
RETURN 'RET'	REGISTER INDIR.	(SP) (SP+1)	C9	D8	D0	C8	C0	E8	E0	F8	F0	
RETURN FROM INT 'RETI'	REGISTER INDIR.	(SP) (SP+1)	ED 4D									
RETURN FROM NON MASKABLE INT 'RETN'	REGISTER INDIR.	(SP) (SP+1)	ED 45									

NOTE – CERTAIN FLAGS HAVE MORE THAN ONE PURPOSE. REFER TO Z80 CPU TECHNICAL MANUAL FOR DETAILS.

RESTART GROUP

		OP CODE		
CALL ADDRESS	0000_H	C7	'RST 0'	0
	0008_H	CF	'RST 8'	1
	0010_H	D7	'RST 16'	2
	0018_H	DF	'RST 24'	3
	0020_H	E7	'RST 32'	4
	0028_H	EF	'RST 40'	5
	0030_H	F7	'RST 48'	6
	0038_H	FF	'RST 56'	7

CALL AND RETURN GROUP

Mnemonic	Symbolic Operation	Flags S	Z		H		P/V	N	C	Op Code 76 543 210	Hex	No. of Bytes	No. of M Cycles	No. of T States	Comments
CALL nn	(SP-1) ← PC_H (SP-2) ← PC_L PC ← nn	•	•	X	•	X	•	•	•	11 001 101 – n – – n –	CD	3	5	17	
CALL cc, nn	If condition cc is false	•	•	X	•	X	•	•	•	11 cc 100 – n – – n –		3	3	10	If cc is false
	continue, otherwise same as CALL nn											3	5	17	If cc is true
RET	PC_L ← (SP) PC_H ← (SP+1)	•	•	X	•	X	•	•	•	11 001 001	C9	1	3	10	
RET cc	If condition cc is false	•	•	X	•	X	•	•	•	11 cc 000		1	1	5	If cc is false
	continue, otherwise same as RET											1	3	11	If cc is true
RETI	Return from interrupt	•	•	X	•	X	•	•	•	11 101 101 01 001 101	ED 4D	2	4	14	
RETN[1]	Return from non maskable interrupt	•	•	X	•	X	•	•	•	11 101 101 01 000 101	ED 45	2	4	14	
RST p	(SP-1) ← PC_H (SP-2) ← PC_L PC_H ← 0 PC_L ← p	•	•	X	•	X	•	•	•	11 t 111		1	3	11	

cc	Condition	
000	NZ	non zero
001	Z	zero
010	NC	non carry
011	C	carry
100	PO	parity odd
101	PE	parity even
110	P	sign positive
111	M	sign negative

t	p
000	00H
001	08H
010	10H
011	18H
100	20H
101	28H
110	30H
111	38H

[1] RETN loads IFF_2 → IFF_1

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown,
↕ = flag is affected according to the result of the operation.

INPUT GROUP

INPUT DESTINATION			PORT ADDRESS: IMMED. n	PORT ADDRESS: REG. INDIR. (C)
INPUT 'IN'	REG. ADDRESSING	A	DB n	ED 78
		B		ED 40
		C		ED 48
		D		ED 50
		E		ED 58
		H		ED 60
		L		ED 68
'INI' – INPUT & Inc HL, Dec B	REG. INDIR.	(HL)		ED A2
'INIR' – INP, Inc HL, Dec B, REPEAT IF B≠0				ED B2
'IND' – INPUT & Dec HL, Dec B				ED AA
'INDR'–INPUT,Dec HL Dec B, REPEAT IF B≠0				ED BA

BLOCK INPUT COMMANDS

OUTPUT GROUP

			SOURCE: REGISTER A	B	C	D	E	H	L	REG. IND. (HL)
'OUT'	IMMED.	n	D3 n							
	REG. IND.	(C)	ED 79	ED 41	ED 49	ED 51	ED 59	ED 61	ED 69	
'OUTI' – OUTPUT Inc HL, Dec b	REG. IND.	(C)								ED A3
'OTIR' – OUTPUT, Inc HL, Dec B, REPEAT IF B≠0	REG. IND	(C)								ED B3
'OUTD' – OUTPUT Dec HL Dec B	REG. IND.	(C)								ED AB
'OTDR'–OUTPUT, Dec HL Dec B, REPEAT IF B ≠ 0	REG. IND.	(C)								ED B8

BLOCK OUTPUT COMMANDS

PORT DESTINATION ADDRESS

INPUT AND OUTPUT GROUP

Mnemonic	Symbolic Operation	Flags S	Z	H	P/V	N	C	Op-Code 76 543 210	Hex	No. of Bytes	No. of M Cycles	No. of T States	Comments
IN A, (n)	A ← (n)	•	•	X	•	X	•	•	11 011 011 ← n →	DB	2	3	11	n to $A_0 \sim A_7$ Acc to $A_8 \sim A_{15}$
IN r, (C)	r ← (C) if r = 110 only the flags will be affected	‡	‡	X	‡	X	P	0	•	11 101 101 01 r 000	ED	2	3	12	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$
INI	(HL) ← (C) B ← B - 1 HL ← HL + 1	X	‡ ①	X	X	X	1	•	11 101 101 10 100 010	ED A2	2	4	16	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$
INIR	(HL) ← (C) B ← B - 1 HL ← HL + 1 Repeat until B = 0	X	1 ①	X	X	X	1	•	11 101 101 10 110 010	ED B2	2 2	5 (if B ≠ 0) 4 (if B = 0)	21 16	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$
IND	(HL) ← (C) B ← B - 1 HL ← HL - 1	X	‡ ①	X	X	X	1	•	11 101 101 10 101 010	ED AA	2	4	16	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$
INDR	(HL) ← (C) B ← B - 1 HL ← HL - 1 Repeat until B = 0	X	1 ①	X	X	X	1	•	11 101 101 10 111 010	ED BA	2 2	5 (if B ≠ 0) 4 (if B = 0)	21 16	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$
OUT (n), A	(n) ← A	•	•	X	•	X	•	•	11 010 011 ← n →	D3	2	3	11	n to $A_0 \sim A_7$ Acc to $A_8 \sim A_{15}$
OUT (C), r	(C) ← r	•	•	X	•	X	•	•	11 101 101 01 r 001	ED	2	3	12	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$
OUTI	(C) ← (HL) B ← B - 1 HL ← HL + 1	X	‡ ①	X	X	X	1	•	11 101 101 10 100 011	ED A3	2	4	16	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$
OTIR	(C) ← (HL) B ← B - 1 HL ← HL + 1 Repeat until B = 0	X	1 ①	X	X	X	1	•	11 101 101 10 110 011	ED B3	2 2	5 (if B ≠ 0) 4 (if B = 0)	21 16	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$
OUTD	(C) ← (HL) B ← B - 1 HL ← HL - 1	X	‡ ①	X	X	X	1	•	11 101 101 10 101 011	ED AB	2	4	16	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$
OTDR	(C) ← (HL) B ← B - 1 HL ← HL - 1 Repeat until B = 0	X	1 ①	X	X	X	1	•	11 101 101 10 111 011	ED BB	2 2	5 (if B ≠ 0) 4 (if B = 0)	21 16	C to $A_0 \sim A_7$ B to $A_8 \sim A_{15}$

Notes: ① If the result of B - 1 is zero the Z flag is set, otherwise it is reset.

Flag Notation: • = flag not affected, 0 = flag reset, 1 = flag set, X = flag is unknown,
‡ = flag is affected according to the result of the operation.

MASKABLE ($\overline{INT}$)

Mode 0

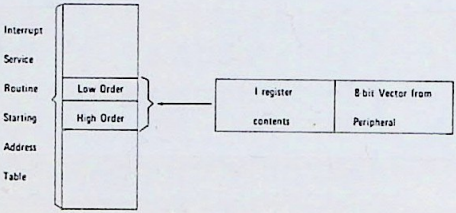
Place instruction onto Data Bus during $\overline{INTA} \cdot \overline{M1} \cdot \overline{IORQ}$ like 8080A

Mode 1

Restart to 38_H or 56_{10} ('RST 56')

Mode 2

Used by Z80 Peripherals



NON MASKABLE ($\overline{NMI}$)

Restart to 66_H or 102_{10}

INTERRUPT ENABLE/DISABLE FLIP-FLOPS

Action	IFF_1	IFF_2	
CPU Reset	0	0	
DI	0	0	
EI	1	1	
LD A, I	•	•	IFF_2 = Parity flag
LD A, R	•	•	IFF_2 = Parity flag
Accept $\overline{NMI}$	0	•	
RETN	IFF_2	•	IFF_2 = IFF_1
Accept $\overline{INT}$	0	0	
RETI	•	•	

"•" indicates no change

REGISTER SELECTION

SELECT LINES C/D	SELECT LINES B/A	REGISTER SELECTED
0	0	A Data
0	1	B Data
1	0	A Control
1	1	B Control

LOAD INTERRUPT VECTOR

D7							D0	
V7	V6	V5	V4	V3	V2	V1	0	Control Register

SET OPERATING MODE

D7							D0	
M1	M0	X	X	1	1	1	1	Control Register

Mode Number	M1	M0	Mode
0	0	0	Output
1	0	1	Input
2	1	0	Bidirectional
3	1	1	Bit Control

If Mode 3 selected, the next control word to the PIO is

D7							D0	
I/O_7	I/O_6	I/O_5	I/O_4	I/O_3	I/O_2	I/O_1	I/O_0	Control Register

I/O = 1 Sets bit to Input

I/O = 0 Sets bit to Output

SET INTERRUPT CONTROL

D7							D0	
Int Enable	AND/ OR	High/ Low	Mask Follows	0	1	1	1	Control Register

In Mode 3 if Mask follows = 1, the next control word to the PIO is

D7							D0	
MB_7	MB_6	MB_5	MB_4	MB_3	MB_2	MB_1	MB_0	Control Register

MB = 0 Monitor the bit

MB = 1 Mask the bit

ENABLE / DISABLE INTERRUPTS

D7							D0	
Int Enable	X	X	X	0	0	1	1	Control Register

CTC PROGRAMMING SUMMARY

REGISTER SELECTION

SELECT LINES CS_1	SELECT LINES CS_0	CHANNEL SELECTED	PRIORITY
0	0	0	Highest
0	1	1	
1	0	2	
1	1	3	Lowest

READ = DOWN COUNTER WRITE = CONTROL REGISTER

LOAD INTERRUPT VECTOR

$CS_0 = CS_1 = 0$

D7							D0	
V_7	V_6	V_5	V_4	V_3	X	X	0	Control Register

XX is the binary equivalent of interrupting channel number

SET OPERATING MODE

Timer Mode only

D7							D0	
Interrupt Enable	Mode	Range	Slope	Trigger	Load Time Constant	Reset	1	Control Register
	Counter/Timer	256/16	+/−	On/Off				

If Load Time Constant = 1 the next control word is the Time Constant:

D7							D0
TC_7	TC_6	TC_5	TC_4	TC_3	TC_2	TC_1	TC_0

CTC Channel interrupts when 01_H is decremented to 00_H

Time Content	Decimal counts to interrupt
01_H	1
.	.
.	.
FF_H	255
00_H	256

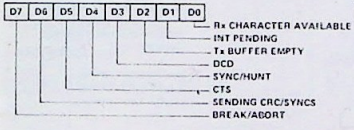
SIO PROGRAMMING SUMMARY

CHANNEL SELECTION

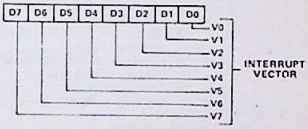
C/D	B/A	FUNCTION
0	0	Channel A Data
0	1	Channel B Data
1	0	Channel A Commands/Status
1	1	Channel B Commands/Status

READ REGISTERS

READ REGISTER 0

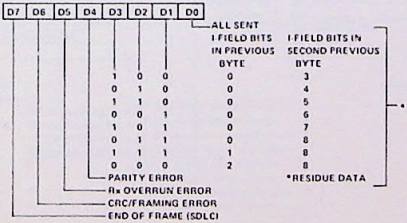


READ REGISTER 2*



*Can Only Be Read By Channel B

READ REGISTER 1

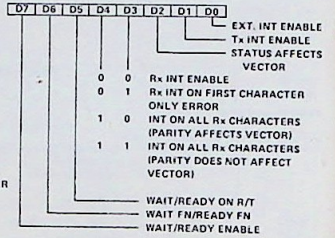


WRITE REGISTERS

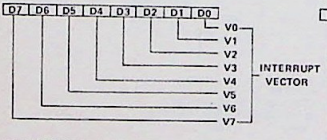
WRITE REGISTER 0

D7	D6	D5	D4	D3	D2	D1	D0	
					0	0	0	REGISTER 0
					0	0	1	REGISTER 1
					0	1	0	REGISTER 2
					0	1	1	REGISTER 3
					1	0	0	REGISTER 4
					1	0	1	REGISTER 5
					1	1	0	REGISTER 6
					1	1	1	REGISTER 7
		0	0	0				NULL CODE
		0	0	1				SEND ABORT (SDLC)
		0	1	0				RESET EXT. STATUS INTERRUPTS
		0	1	1				CHANNEL RESET
		1	0	0				RESET Rx INT ON FIRST CHARACTER
		1	0	1				RESET Tx INT PENDING
		1	1	0				ERROR RESET
		1	1	1				RETURN FROM INT (CH-A-ONLY)
0	0	NULL CODE						
0	1	RESET Rx CRC CHECKER						
1	0	RESET Tx CRC GENERATOR						
1	1	RESET CRC/SYNCS SENT/SENDING LATCH						

WRITE REGISTER 1

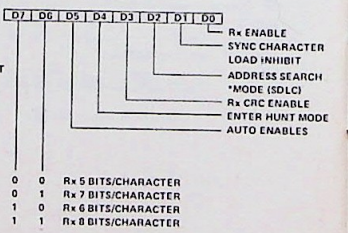

D7 D6 D5 D4 D3 D2 D1 D0
EXT. INT ENABLE
Tx INT ENABLE
STATUS AFFECTS VECTOR
0 0 Rx INT ENABLE
0 1 Rx INT ON FIRST CHARACTER ONLY ERROR
1 0 INT ON ALL Rx CHARACTERS (PARITY AFFECTS VECTOR)
1 1 INT ON ALL Rx CHARACTERS (PARITY DOES NOT AFFECT VECTOR)
WAIT/READY ON R/T
WAIT FN/READY FN
WAIT/READY ENABLE

WRITE REGISTER 2*

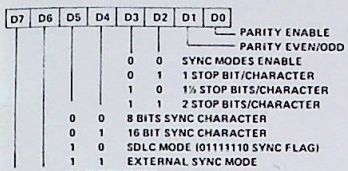


*Can Only Be Written By Channel B

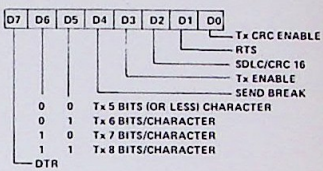
WRITE REGISTER 3


D7 D6 D5 D4 D3 D2 D1 D0
Rx ENABLE
SYNC CHARACTER LOAD INHIBIT
ADDRESS SEARCH *MODE (SDLC)
Rx CRC ENABLE
ENTER HUNT MODE
AUTO ENABLES
0 0 Rx 5 BITS/CHARACTER
0 1 Rx 7 BITS/CHARACTER
1 0 Rx 6 BITS/CHARACTER
1 1 Rx 8 BITS/CHARACTER

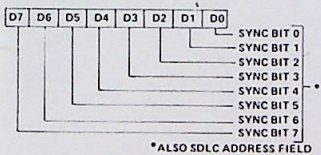
WRITE REGISTER 4


D7 D6 D5 D4 D3 D2 D1 D0
PARITY ENABLE
PARITY EVEN/ODD
0 0 SYNC MODES ENABLE
0 1 1 STOP BIT/CHARACTER
1 0 1½ STOP BITS/CHARACTER
1 1 2 STOP BITS/CHARACTER
0 0 8 BITS SYNC CHARACTER
0 1 16 BIT SYNC CHARACTER
1 0 SDLC MODE (01111110 SYNC FLAG)
1 1 EXTERNAL SYNC MODE
0 0 X1 CLOCK MODE
0 1 X16 CLOCK MODE
1 0 X32 CLOCK MODE
1 1 X64 CLOCK MODE

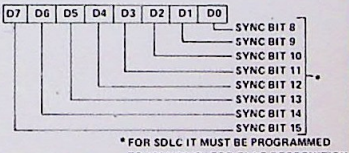
WRITE REGISTER 5



WRITE REGISTER 6



WRITE REGISTER 7


D7 D6 D5 D4 D3 D2 D1 D0
SYNC BIT 8
SYNC BIT 9
SYNC BIT 10
SYNC BIT 11
SYNC BIT 12
SYNC BIT 13
SYNC BIT 14
SYNC BIT 15
*FOR SDLC IT MUST BE PROGRAMMED TO "01111110" FOR FLAG RECOGNITION

STATUS AFFECTS VECTOR (D_2) (FROM WRITE REG 1)

If this mode is selected, the vector returned from an interrupt acknowledge cycle will be variable according to the following:

	V_3	V_2	V_1	
Ch B	0	0	0	Ch B Transmit Buffer Empty
	0	0	1	Ch B External/Status Change
	0	1	0	Ch B Receive Character Available
	0	1	1	Ch B Special Receive Condition
Ch A	1	0	0	Ch A Transmit Buffer Empty
	1	0	1	Ch A External/Status Change
	1	1	0	Ch A Receive Character Available
	1	1	1	Ch A Special Receive Condition

If this bit is 0, the fixed vector programmed in the vector register is returned.

NOTES

ASCII CHARACTER SET (7-BIT CODE)

MSD / LSD		0 000	1 001	2 010	3 011	4 100	5 101	6 110	7 111
0	0000	NUL	DLE	SP	0	@	P	`	p
1	0001	SOH	DC1	!	1	A	Q	a	q
2	0010	STX	DC2	"	2	B	R	b	r
3	0011	ETX	DC3	#	3	C	S	c	s
4	0100	EOT	DC4	$	4	D	T	d	t
5	0101	ENG	NAK	%	5	E	U	e	u
6	0110	ACK	SYN	&	6	F	V	f	v
7	0111	BEL	ETB	'	7	G	W	g	w
8	1000	BS	CAN	(	8	H	X	h	x
9	1001	HT	EM	)	9	I	Y	i	y
A	1010	LF	SUB	*	:	J	Z	j	z
B	1011	VT	ESC	+	;	K	[	k	
C	1100	FF	FS	,	<	L	\	l	|
D	1101	CR	GS	-	=	M	]	m	
E	1110	SO	RS	.	>	N	↑	n	~
F	1111	SI	VS	/	?	O	←	o	DEL

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